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CONTROL OF SCLEROTINIA STEM ROT IN SMALL-SEEDED LENTIL PRODUCTION IN THE BLACK SOIL ZONE

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Control of Sclerotinia Stem Rot in Small-seeded Lentil Production in the Black Soil Zone

Project **19990340**

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Final Report

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(a) Abstract/Summary

Management strategies for Sclerotinia stem rot in small-seeded lentils in the Black Soil zone were investigated at Rosthern and Melfort. At both locations, severe drought conditions during the cropping seasons 2001 and 2002 resulted in poor crop development and no significant incidence of Sclerotinia white mold or other foliar diseases. Weather conditions in 2000 were conducive to crop establishment and disease development. Field experiments showed that plant density, regulated through row spacing, had no significant effect on disease severity. Fungicide treatment at both locations significantly reduced disease in comparison to the control. Individual fungicide efficacy and optimal timing of application was influenced by location and varieties. Yield increase through fungicide application was observed in Melfort where the disease was more severe than in Rosthern. Revenues from plots with different treatments were variable, but at higher disease pressure at Melfort all fungicide treated plots had higher returns than the control. In Rosthern, but not in Melfort, flower petal infection was positively correlated with disease in the field.

(b) Executive Summary

Sclerotinia stem rot, caused by the fungal pathogen *Sclerotinia sclerotiorum* (Lib.) de Bary has been a serious problem in lentil production in years when late season precipitation occurs. Resistance to the pathogen has not been identified and recommendations on efficient disease management are not available in this crop. Field experiments were conducted for 3 years between 2000 and 2002 under dryland conditions at two locations (Rosthern and Melfort). At Melfort the crop canopy was misted using a mist irrigation system to encourage Sclerotinia infection. The objective was to study the influence of plant density (50 and 100 plants m^{-2}), the efficacy of different fungicides (Benlate, Rovral Flo) and the timing of fungicide application (early flowering and late flowering) on the development of the disease. Three lentil varieties ('CDC Milestone', 'CDC Robin' and 'Crimson') were tested. Laboratory plate tests were conducted to monitor flower petal infection, which may be indicator for disease severity in the field.

At both locations, severe drought conditions during the growing seasons 2001 and 2002 resulted in poor plant development. Short plants did not produce a closed canopy conducive to disease development, and no significant development of Sclerotinia white mold occurred. This was despite the fact that some levels of flower infection with the fungus were detected in flower petal tests suggesting that conditions were too dry for further infection from the flower petals into the lentil plants.

In 2000, good growing conditions resulted in a normal plant stand and moderately high disease development. Levels of petal infection and disease severity were higher at Melfort due to canopy misting, more precipitation and possibly higher inoculum levels. At both locations, some of the fungicide applications significantly reduced disease severity in comparison to the unsprayed control plots. Among the three varieties, 'CDC Robin' showed lowest levels of disease, followed by 'CDC Milestone' and 'Crimson'. On average, Benlate performed better than Rovral Flo, but the optimal timing of the application varied at both locations. At Rosthern, performance of fungicides also appeared to be dependent on the variety, but generally late applications of the fungicides were more effective than early application. At Melfort, early application of Benlate performed best across all varieties, but was followed by early application of Rovral Flo.

Although some fungicide treatments reduced disease in both experiments, a significant yield increase in comparison to the unsprayed control was observed only at Melfort. Generally, late fungicide application resulted in higher yields compared to early fungicide application, but varieties had a significant influence. Among varieties, 'CDC Robin' had the lowest yield while 'Crimson' performed best, in spite of having the highest disease levels. Crimson produces a smaller canopy compared to the other varieties, suggesting that specific varieties may be more productive under conditions that favor Sclerotinia development. Economic returns from plots with different treatments were variable, but at higher disease pressure at Melfort, all fungicide treated plots had higher returns compared to control treatments.

Plant density had no significant effect on disease development at either location. Plant density was regulated through variation in row spacing, with 8" (narrow) and 16" (wide) rows at Rosthern, and 9" (narrow) and 18" (wide) rows at Melfort (100 and 50 plants m^{-2}, respectively). Plant density within the rows was similar for both spacings. Even though plants in plots with wide rows compensated well for lower plant density, plants did not form a closed canopy across the whole plot. However, restricted air movement and contact of lodged plants with the soil increased plant wetness and thus promoted disease development resulting in similar disease levels for all treatments. This observation raises the question whether differences in disease severity can be obtained through regular spacing of 50 or 100 plants m^{-2}, i.e. through variation of within and between row spacing.

While row spacing and plant density did not affect disease development, yield was significantly lower in plots with wide rows (50 plants m^{-2}). At Rosthern, wide rows yielded on average 20% less than those with narrow rows (100 plants m^{-2}), while at Melfort, under higher disease pressure, the difference in yield was at approximately 10%. These results show that lentil has a considerable ability to compensate for lower plant density.

Flower petals were collected from beginning to end of flowering in weekly intervals. Similar to field disease ratings, flower petals at Melfort had higher disease levels (average infection of 53 %) compared to those from Rosthern (average infection of 36 %). At Rosthern it was demonstrated that the infection rate in flower petals was positively correlated to the final disease levels in the field. At Melfort, this relationship was not present.

Little is known about the epidemiology of Sclerotinia in lentil. It was suspected that it infects plants through flower petals, similar to the process demonstrated in bean and in canola. Considerable differences in the effects of fungicide, timing and variety performance as observed in this project, may therefore be due to differences in the physiological development of plants, e.g. the timing and duration of flowering. At this

point, it is not possible to issue recommendations for control of Sclerotinia. Further research is required for the development of a control strategy.

(c)Technical Report

Background:

Lentil production was estimated at 1.8 million acres in 2000 (Statistics Canada), most of which was grown in Saskatchewan. Production could increase over the next few years in response to market demand and poor prices for other crops. An estimated 10 to 20 % of the lentil production is found in the black soil zone. Good yield potential in these areas and efforts to breed better adapted varieties for the black soil zone make small-seeded lentil, in particular small red and small green types, an increasingly attractive cash crop. Lush growth and microclimatic conditions characterized by higher precipitation and humidity render lentil more prone to infection with Sclerotinia stem rot in these areas. Resistance to the disease has not been well characterized and reliable control strategies are lacking. If successful control strategies are realized, the project will have immediate impact on red lentil production, the fastest growing segment of the lentil export market.

Project objectives:

The objectives of this project were to determine strategies for disease control of Sclerotinia stem rot in small-seeded lentil by studying the influence of variety, plant density, the efficacy of different fungicides and the timing of fungicide applications on disease development. The economics of various control strategies will be evaluated.

Materials and Methods:

Field experiments:

Two experiments were initiated each in 2000, 2001 and 2002 under dryland conditions at Rosthern and Melfort. At Melfort the crop canopy was misted during flowering. The experiments included three lentil varieties ('CDC Milestone', 'CDCRobin' and 'Crimson'), five different fungicides treatments, two different plant densities (100 plants m^{-2} and 50 plants m^{-2}) in three replications (RCBD).

In 2000, the experiments were seeded in early May at both locations. Different plant densities were obtained by varying the row spacing. In plots with a final plant density of 100 plants m^{-2}, lentil were planted in 8" (Rosthern) or 9" (Melfort) rows, and in plots with 50 plants m^{-2} rows were spaced 16" (Rosthern) and 18" (Melfort). Plots were treated either with an application of Benlate at early flowering, an application with the same fungicide at late flowering, or with an application of Rovral Fl at early or late flowering. Control plots were not protected with a fungicide. Rovral Flo was sprayed at a rate of 1.2 l/acre and Benlate at 0.4 kg/acre, with early applications at 25 % bloom stage and late application at 60 % bloom stage. First disease ratings were taken approximately 3.5 weeks before harvest, a second rating was conducted approximately 2 weeks before harvest. Results of the final rating are presented. Within each plot, 10 randomly selected plants were scored on a scale from 0 -no symptoms to 5 - main stem lesions affecting entire plant (Table 1).

In 2001, experiments were established as in 2000, but lentil were seeded at 8" (Rosthern) or 9" (Melfort) row spacing only and plant density was regulated through intra-row plant density to obtain 50 or 100 plants m^{-2}. Fungicide applications were conducted as above. Fields were scouted for disease several times but severe drought conditions at both locations prevented disease development.

In 2002, Benlate was replaced with Quadris because Benlate was no longer available.

Flower Petal Test:

For petal tests only flowers from the untreated control plots with the 100 plants m^{-2} were used. Twelve flowers were randomly picked from each of these plots in 2000, 2001 and 2002. One petal of each flower was removed and plated on Potato Dextrose Agar (PDA) amended with Streptomycin (0.1g/l PDA)(4 petals per Petri dish). Plots were sampled 6 times at Rosthern and 4 times at Melfort. Four to 5 days after transferring onto plates, Petri dishes were evaluated by counting the number of petals with colonies of Sclerotinia-like mycelium.

Observations:

In 2001 and 2002, large parts of Saskatchewan including Rostern and Melfort experienced severe droughts. As a consequence, plant establishment was poor, plants were stunted and matured irregularly. Conditions were too dry for Sclerotinia white mold or other diseases to establish at Rosthern in both years. Very low levels of Sclerotinia white mold were detected at Melfort in 2001, but were well below 1 on the rating scale. Disease data was therefore not further analyzed. No disease was observed at Melfort in 2002. At Rosthern, extremely low levels of petal infection were observed (< 4%) in 2001, and less than 1 % in 2002. In 2001 at Melfort, petal infection started and peaked at 64 % infection and decreased during the following weeks to 14 and 25 %. This suggests that moisture due to the misting irrigation was sufficient for ascospores to infect the flower petals, but that conditions were too dry for further infection from these flower petals into the lentil plants. Flower petal infection in 2002 was significantly reduced to levels below 5 %.

Good growing conditions and sufficient moisture for disease establishment were experienced in 2000 and results of the experiments from this year are discussed below.
In both experiments, infection with *Ascochyta lentis* and *Colletotrichum truncatum* (Anthracnose) was very low. Low levels of Botrytis were observed at Rosthern, while none was recorded at Melfort.

Sclerotinia infection occurred late in the season after canopy closure. Disease severity at Rosthern was lower than at Melfort, most likely due to differences in local microclimate. At Rosthern, 'CDC Robin' had lowest disease severity ratings in all treatments while Crimson tended to have highest infection rates. In untreated control plots, 'CDC Robin' performed best with significantly less disease than 'Crimson' and 'CDC Milestone', suggesting that this variety has some genetic resistance to the pathogen. However, at Melfort, Robin and Milestone performed similarly across all treatments. Crimson was most susceptible at Melfort, too (Figure 1).

Fungicide treatments did not show consistent results across the two experiments (Figure 1). At Rosthern, varieties reacted differently towards fungicide treatments while in Melfort this interaction was not observed. At Rosthern, 'CDC Milestone' had significantly lower disease ratings in all fungicide treated plots in comparison to unsprayed control plots. Among fungicide treatments, late application of Benlate resulted in the lowest disease levels. For 'CDC Robin', early application of both fungicides did not reduce disease in comparison to the untreated control. For 'Crimson', the late application of Benlate reduced disease significantly in comparison to all other treatments. Generally, late application was better than early application, suggesting that infection pressure was higher at late bloom.

At Melfort, there were no significant differences among the control, Rovral Flo early and Benlate late. Rovral Flo late and Benlate early, however, reduced disease severity significantly in all varieties. Differences in the effect of timing at Rosthern and Melfort are most likely due to local weather conditions and use of canopy misting at the critical time of infection.

At Rosthern, plant density had no consistent effect on disease control (Figure 2). For Benlate and control treatments, higher disease scores were recorded for plots with higher plant densities, but differences were not significant. In plots sprayed with Rovral Flo, the trend was reversed in that plots with low plant density had the higher disease score. This difference was significant in case of the late application of Rovral Flo. In plots with 100 plants m^{-2}, late application of Rovral Flo and Benlate reduced disease significantly in comparison to early application and the control. In plots with lower plant density, only late application of Benlate reduced disease significantly. At Melfort, differences between plots with different plant densities were not significant, but higher plant stand showed the tendency of promoting disease development.

At Rosthern, application of fungicide had no significant effect on yield, but plots with 100 plants m^{-2} had significantly higher yield (average increase of 20 %) than those with 50 plants m^{-2} (data not shown). 'CDC Robin', the variety with lowest disease scores had

significantly lower yields than both 'Crimson' and 'CDC Milestone'. 'CDC Milestone' yielded on average 6 % more than 'Crimson' and 17 % more than 'CDC Robin' (Figure 3).

At Melfort, yields were lower. Furthermore, treatment effects were observed but varied with variety and plant density. Generally, late fungicide application resulted in higher yield compared to early application. On average, higher plant density only resulted in higher yields in a few plots, mostly those with 'CDC Robin' and 'CDC Milestone'. Yield was about 20 % higher in plots with a higher plant density.

Results of the flower petal tests showed at both locations that infection of flower petals by ascospores of *S. sclerotiorum* occurred throughout the flowering period. Average petal infection increased after early bloom from approximately 20 % to over 70 % and was highest at late bloom (data not shown). At Melfort, no significant correlation was detected between the average proportion of flower infection (53 %) and final disease rating (R=-0.362, P=0.3385), while at Rosthern average flower infection (36 %)was correlated with final disease severity (R=0.661, P=0.0526) (Fig.4).

Figure 1: Control of *Sclerotinia sclerotiorum* in small-seeded lentil varieties ''CDC Milestone'', ''CDC Robin'' and ''Crimson'' in plots with 2 different plant densities (8"/9" rows with 100 plants m^{-2} and 16"/18" rows with 50 plants m^{-2}). through application of Benlate and Rovral Flo, respectively. Early sprays were applied at the 25 % bloom stage, late sprays at 60 % bloom.

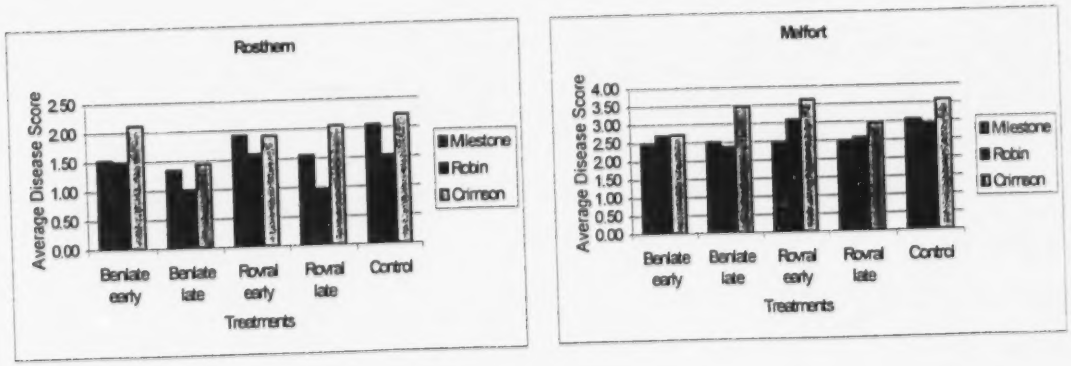


Figure 2: Control of *Sclerotinia sclerotiorum* in three lentil varieties (''CDC Milestone'', ''CDC Robin'' and ''Crimson'') through application of Benlate and Rovral Flo, respectively, in plots with 2 different plant densities (8"/9" rows with 100 plants m^{-2} and 16"/18" rows with 50 plants m^{-2}). Early sprays were applied at the 25 % bloom stage, late sprays at 60 % bloom.

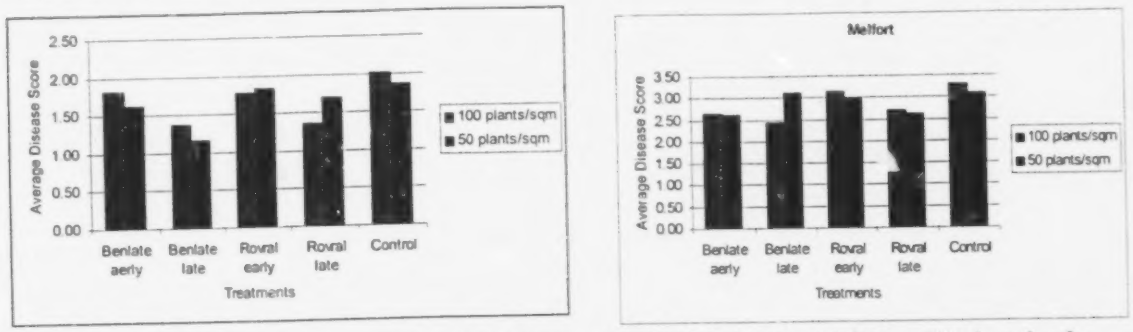


Figure 3: Yield of three lentil varieties (''CDC Milestone'', ''CDC Robin'' and ''Crimson'') planted at 2 plant densities (8"/9" rows with 100 plants m^{-2} and 16'/18' rows with 50 plants m^{-2}) and treated with fungicides (Rovral Flo early and late application, Benlate early and late application, control) for the control of *Sclerotinia sclerotiorum*.

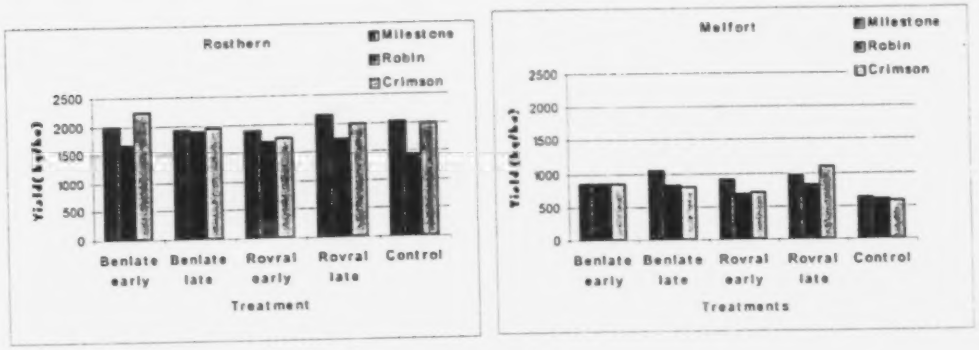
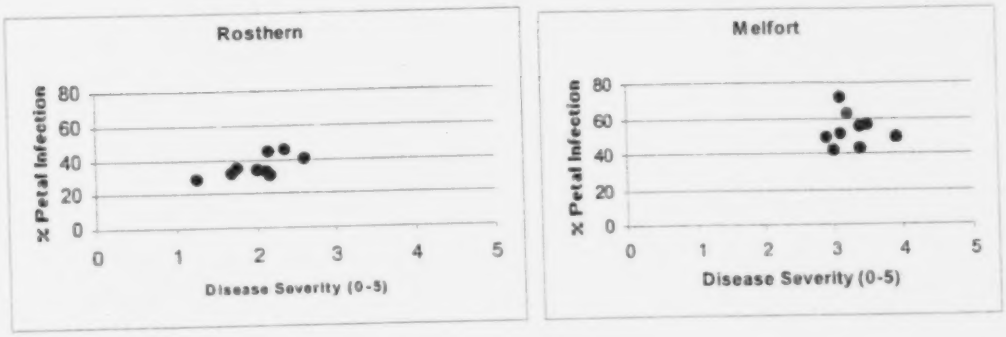


Figure 4: Relation ship between lentil flower infection with *Sclerotinia sclerotiorum* and final disease severity in untreated control plots of field experiments at Melfort and Rosthern to study various disease management options.



Gross revenues per hectare less cost of fungicide and application were calculated for each treatment and variety at both locations. Based on an average price for red lentil of $ 0.37 kg^{-1}, cost per hectare for fungicides of $52 (Benlate)or $79 (Rovral) and application ($10). At Rosthern the revenue of the fungicide treated plots over that of the control varied from a loss of -$177 to a gain of $97 (Table 2). Fungicide application to either Milestone or Crimson always resulted in an economic loss compared to the control (no fungicide). However fungicide application on the variety CDC Robin was always positive although not always by much. Applying Benlate at the second spray date resulted in the greatest economic return for CDC Robin at Rosthern.

At Melfort, gross returns were low for all treatments due to relatively low yields (Table 2). However, the results indicate that under high disease severity, application of fungicide may have an economic benefit. Revenues for each treatment compared to the control (after costs of fungicide and application) varied from a loss of $52 per hectare to a benefit of $111. All cultivars showed a benefit to fungicide application over the check except Rovral applied at the early spray date on CDC Robin and Crimson.
The highest returns were achieved with the late application of Benlate on CDC Milestone and the late application of Rovral on Crimson.

Conclusions:

Results in 2000 on Sclerotinia stem rot control in small seeded lentil production in the black soil zone did not produce consistent results across the two experiments. At Rosthern, late application of Benlate appeared to be the best treatment to reduce disease while at Melfort Benlate early and Rovral Flo late produced best results. Differences at the locations are not unexpected as local growing conditions, humidity and precipitation varied. However, results indicated that yield increase through fungicide application is only encountered when disease levels are relatively high. More data are required to reliably determine a disease threshold beyond which fungicide treatment will have an return in yield and quality. This will be needed to rigorously evaluate the economics of Sclerotinia control, which varied with environment (location), timing of fungicide application and variety of lentil in this study. Similarly to field data, results of the flower petal test, though based on a restricted number of data points to date, did not produce a consistent trend. It is therefore not clear whether this technique may be suitable for the prediction of disease pressure.

Poor soil moisture conditions in spring 2002, and lack of precipitation during the growing seasons of both 2001 and 2002, resulted in poor crop stands plant development. Flowering was irregular and plants remained extremely short. Many plants matured early. Dry air and soil conditions were extremely unfavorable for infection with Sclerotinia. Drought conditions in 2001 may have already reduced the amount of inoculum of the pathogen. Lack of soil moisture in spring of 2002 prevented sclerotia from germinating, preventing production of asci and ascospores, which would normally infect flower petals and eventually lentil plants. The small plants in most plots did not lodge and thus could not be infected directly by the fungus if moisture due to dew was present. Dew also dried off quickly due to unhindered air movement in the open lentil canopy.

Papers / Presentations:

Banniza, S., Kutcher, R., Vandenberg A., (2001): Sclerotinia stem rot in small-seeded lentil production in the black soil zone. Soils & Crops 2000, Saskatoon, February 22-23 [Poster and short paper].

Banniza, S., Kutcher, R., Vandenberg, A., (2000): First year results on Sclerotinia stem rot control in small-seeded lentil production in the black soil zone. In *Third Pulse Crop Research Workshop*, Winnipeg, November 19-21, pp.47-49.

Future Research:

Continued research on cultural and chemical control of Sclerotinia stem rot of lentil is recommended in light of the results of this study. A return to more normal precipitation patterns will likely cause the disease to return, causing concern among lentil producers. In the long term, resistant varieties would help to reduce the economic consequences of this disease. However this will not be achieved in the near future. Research efforts in the control of Sclerotinia stem rot will concentrate on the breeding for resistance to this disease.

Information of benefit to producers, processors, or governments:

No specific recommendations for Sclerotinia control in lentil can be issued at this stage because of the lack of disease development in 2001 and 2002. However, we anticipate that future cycles of high lentil prices will induce production in the black soil areas, and that producers will seek available information. Under these circumstances, we expect Sclerotinia to be a cause of future economic loss. We have some evidence for the existence of genetic differences in tolerance to Sclerotinia, and that these differences may be related to canopy structure and maturity.

We can recommend at this stage that this research could be continued and conducted on a field scale at the Agri-Arm sites at Redvers, Canora, Melfort and Indian Head. The most suitable treatments would include the use of new red lentil varieties like CDC Robin, CDC Blaze and 1254S-1 grown at commercial seeding rates, followed by application of Rovral or other fungicides at late flowering. This will help establish the economic thresholds for fungicide application for late season canopy diseases.

Research on genetic control of resistance to Sclerotinia has commenced at ICARDA and in the Pacific Northwest in anticipation of this disease becoming much more of a problem

in winter lentil production systems. As part of a project focused on developing lentil germplasm with improved Sclerotinia tolerance for future needs in Saskatchewan we are (1) developing recombinant inbred populations (RILs) using ICARDA germplasm as parents, and (2) developing a collaborative research relationship with Dr. Weidong Chen and Dr. Fred Muehlbauer of the USDA at Washington State University. Their research group has received funding from a USDA-sponsored national initiative in the USA to address problems associated with Sclerotinia, one the most widespread diseases of plant agriculture. Dr. Chen has developed a technique for laboratory screening of Sclerotinia tolerance in lentil. Dr. Muehlbauer has identified some US-adapted germplasm with improved tolerance to Sclerotinia.

(d) Personnel:

Sabine Banniza was appointed Pulse Crop Pathologist in the Crop Development Centre in spring 2000. While she still managed the project and was responsible for the overall supervision, technical personnel took over responsibility for the field work at all project locations.

(e) Equipment:

None

(f) Project Developed Materials:

None

(g) Project Photos:

Attached separately

Photo 1: Field experiment at Melfort in 2000 to test control of *Sclerotinia sclerotiorum* in small-seeded lentil varieties ''CDC Milestone'', ''CDC Robin'' and ''Crimson'' in plots with 2 different plant densities (8"/9" rows with 100 plants m^{-2} and 16"/18" rows with 50 plants m^{-2}). through application of Benlate and Rovral Flo, respectively.

Photo 2: Lentil plot with 8" row spacing at Rosthern in 2000.

Photo 3: Lentil plot with 16" row spacing at Rosthern in 2000.

Photo 4: Lentil plants infected with Sclerotinia stem rot. Fungal mycelium on the ground and on lentil stems.

Photo 5: Lentil flowers collected at Rosthern for plate tests.

Photo 6: Lentil flower petals plated onto potato dextrose agar amended with streptomycin to test for infection with *Sclerotinia sclerotiorum*.

Photo 7: Flower petal test plate five days after plating with a colony of *Sclerotinia sclerotiana* developing on the left.

Photo 8: Field experiment at Melfort at 2002 during a severe drought.

(h) Acknowledgement:

The Saskatchewan Agricultural Development Fund has been acknowledged in all presentations (see above) where this research project was mentioned.

Table 1. Sclerotinia stem rot severity assessment scale for lentil based on location of lesions observed on each plant.

Disease severity rating	Symptoms
0	No symptoms
1	Infections limited to pods of the plant
2	¼ of plant affected, usually 1-2 branches
3	½ of plant affected, usually 2-3 branches
4	¾ of plant affected, usually 3 or more branches
5	Main stem lesion near the base affecting entire plant

Table 2: Revenue ($Cdn) per hectare from field trials of disease management strategies for Sclerotinia stem rot of lentil. Calculations include gross revenue less cost of fungicide (Benlate - $52; Rovral FL - $79) and application ($10) for CDC Milestone, CDC Robin and Crimson.

	Rosthern					Melfort				
	Benlate early	**Benlate late**	**Rovral early**	**Rovral late**	**Control**	**Benlate early**	**Benlate late**	**Rovral early**	**Rovral late**	**Control**
CDC Milestone										
Yield [1]	1986	1933	1897	2135	2020	855	1051	901	954	620
Gross revenue[2]	735	715	702	790	747	316	389	333	353	229
Fungicide & application	62	62	89	89		62	62	89	89	
Gross revenue less costs	673	653	613	701	747	254	327	244	264	229
Difference from control	**-74**	**-94**	**-134**	**-46**		**25**	**98**	**15**	**35**	
CDC Robin										
Yield	1673	1880	1699	1716	1453	853	812	697	819	599
Gross revenue[2]	619	696	629	635	537	316	300	258	303	221
Fungicide & application	62	62	89	89		62	62	89	89	
Gross revenue less costs	557	634	540	546	537	254	238	169	214	221
Difference from control	**20**	**97**	**3**	**9**		**33**	**17**	**-52**	**7**	
Crimson										
Yield	2233	1942	1747	1983	1988	864	794	718	1106	565
Gross revenue[2]	826	719	647	734	735	320	294	266	409	209
Fungicide & application	62	62	89	89		62	62	89	89	
Gross revenue less costs	764	657	558	645	735	258	232	177	320	209
Difference from control	**29**	**-78**	**-177**	**-90**		**49**	**23**	**-32**	**111**	

[1] Yield in kg/ha

[2] Revenue in $Cdn based on $ 0.37/kg